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**Motta et al.**

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(54) **USER EXPERIENCE AND DEPENDENCY MANAGEMENT IN A MOBILE DEVICE**

(58) **Field of Classification Search**  
CPC ..... G06F 8/61; G06F 8/65; G06Q 30/02  
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See application file for complete search history.

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**Related U.S. Application Data**

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(57) **ABSTRACT**

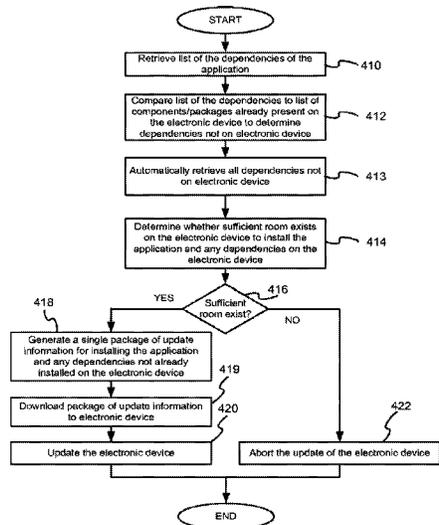
(60) Provisional application No. 60/834,325, filed on Jul. 27, 2006.

A method, system, and device supporting installation of updates to software and/or firmware in memory of an electronic device is described. The update information may be automatically generated based upon a list of all software components or packages already present on the electronic device, and may comprise software components for all dependencies of an application being installed by the update that are not already present on the electronic device.

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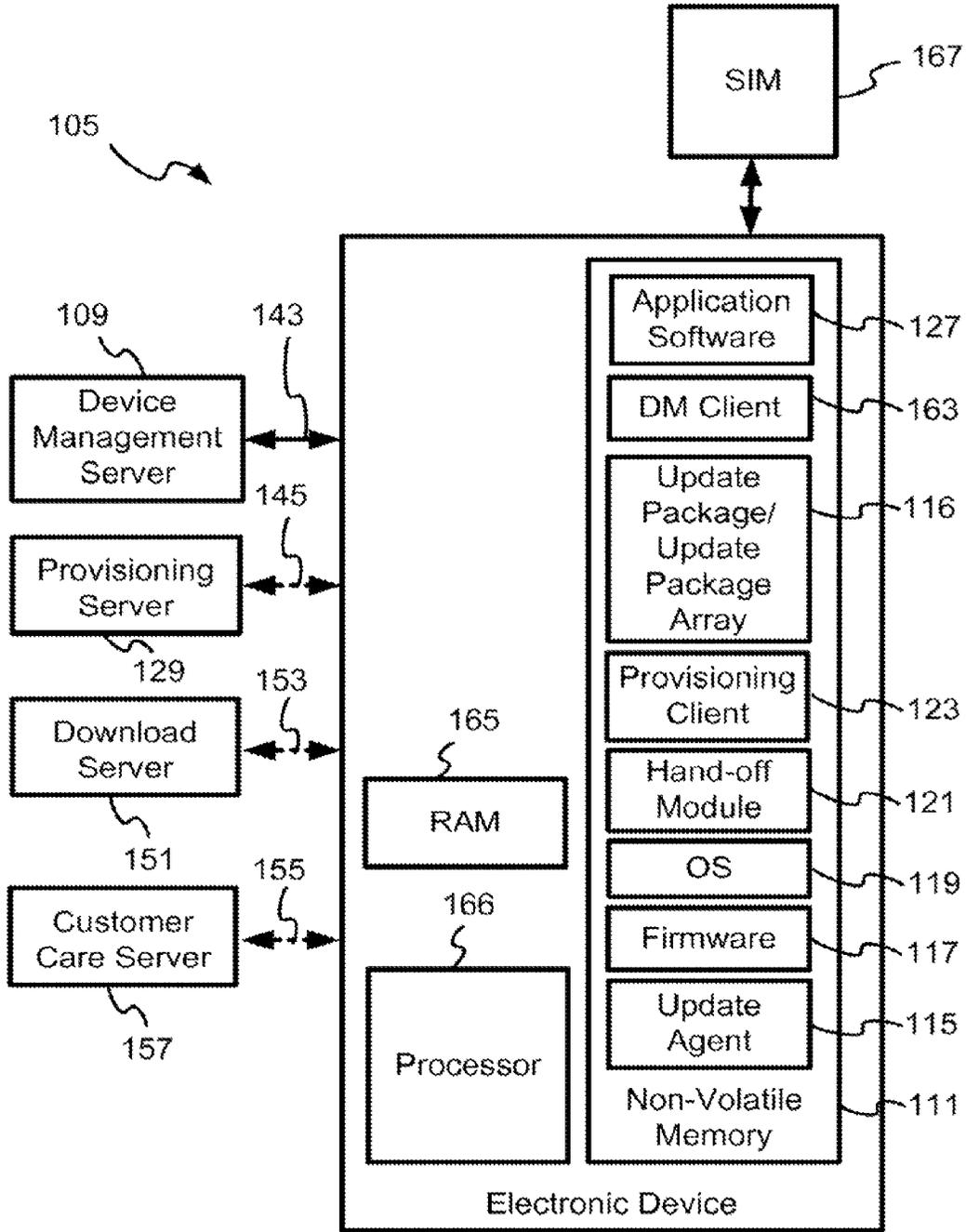


FIG. 1

107

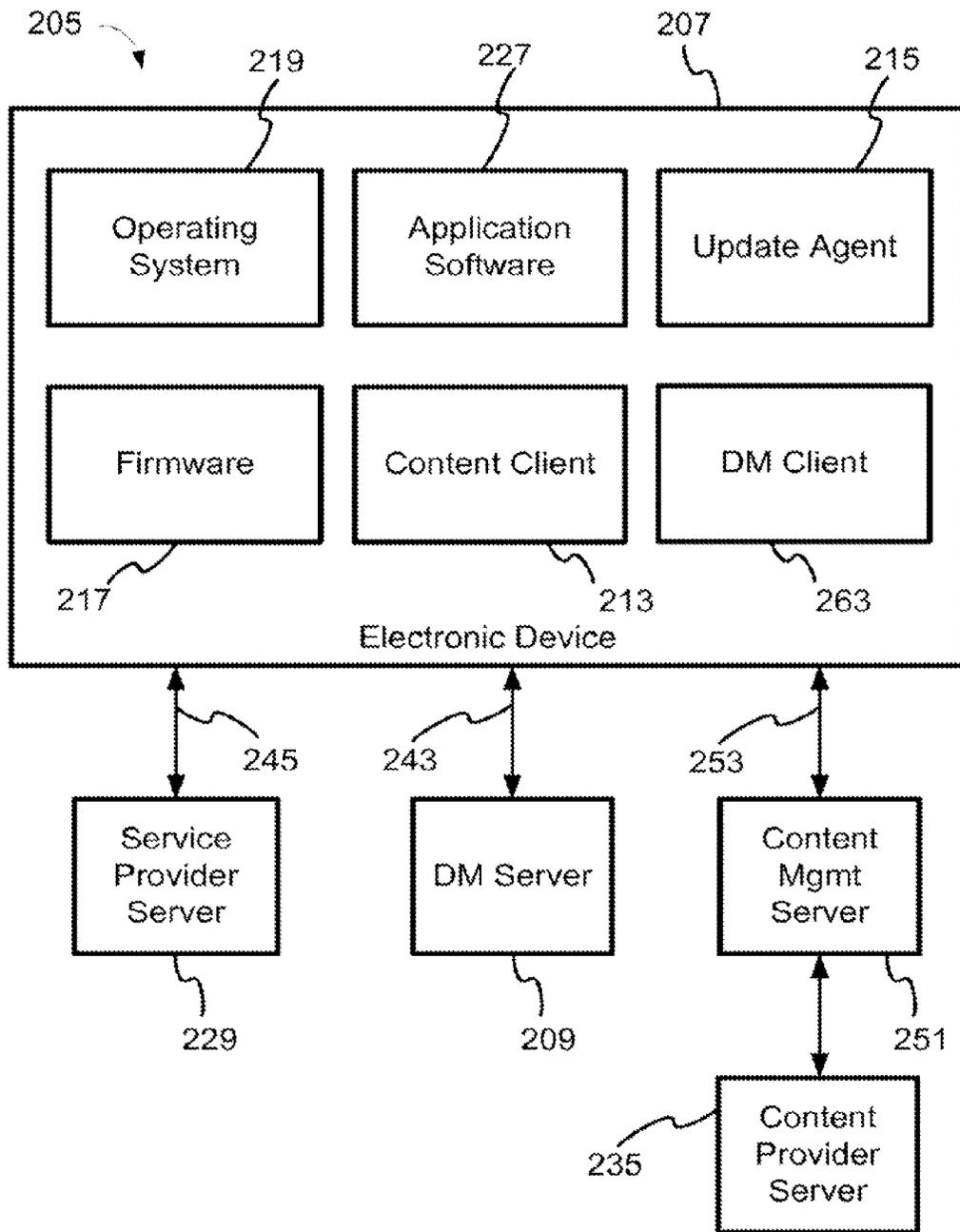


FIG. 2

300

	320	322	324
310	Package A Identifier	Package A Version	Package A Dependency List
312	Package B Identifier	Package B Version	Package B Dependency List
314	Package C Identifier	Package C Version	Package C Dependency List
316	Package D Identifier	Package D Version	Package D Dependency List

**FIG. 3**

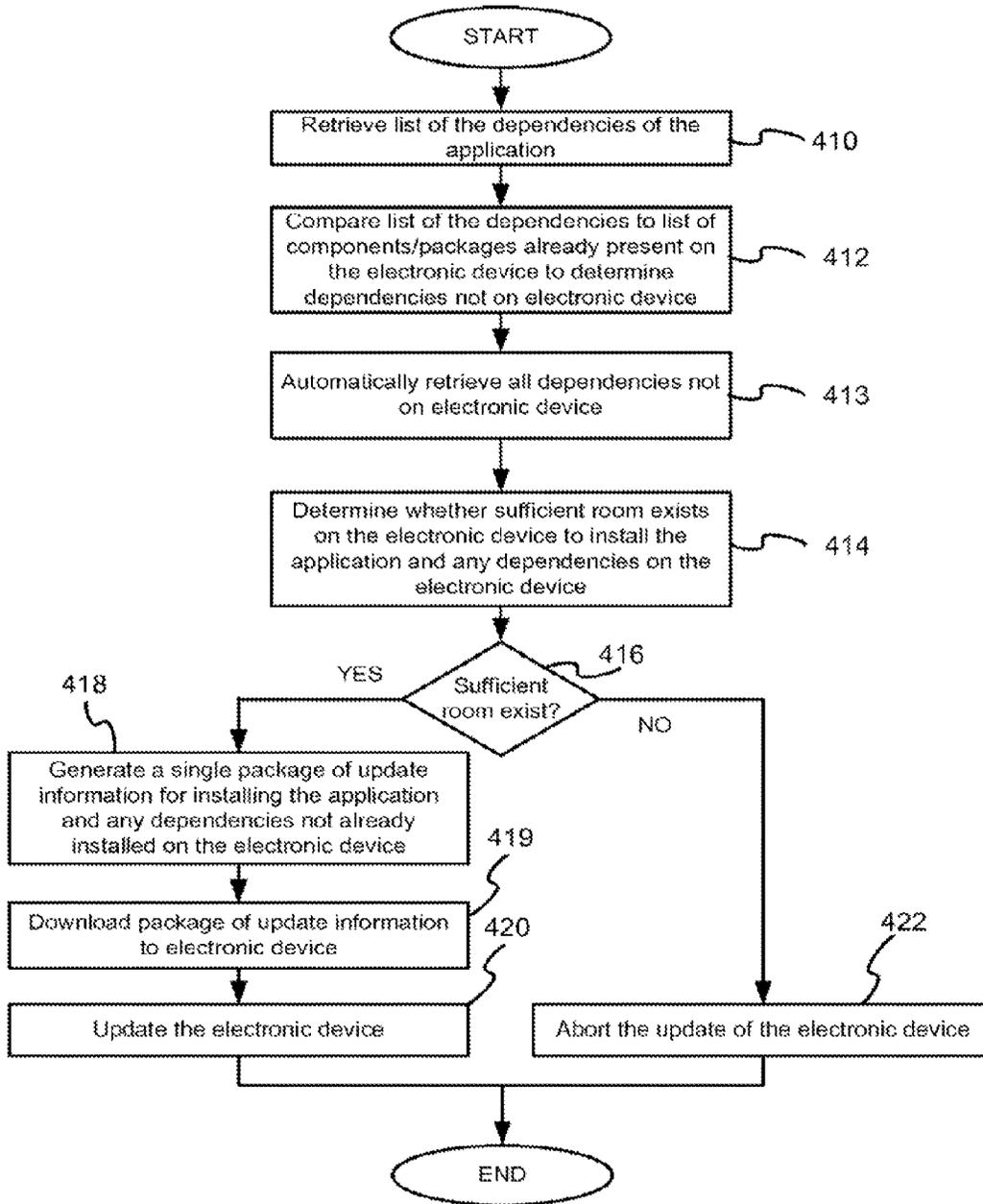


FIG. 4

## USER EXPERIENCE AND DEPENDENCY MANAGEMENT IN A MOBILE DEVICE

### CROSS-REFERENCES TO RELATED APPLICATIONS

The present U.S. patent application is a continuation of U.S. patent application Ser. No. 11/829,520, now U.S. Pat. No. 8,752,044, entitled "User Experience and Dependency Management In a Mobile Device," filed Jul. 27, 2007; which claims priority to U.S. Provisional Patent Application No. 60/834,325, entitled "User Experience and Dependency Management In a Mobile Device," filed Jul. 27, 2006; the entire disclosures of which are incorporated by reference into this application for all purposes.

The present application makes reference to U.S. Provisional Patent Application Ser. No. 60/249,606, entitled "System and Method for Updating and Distributing Information," filed Nov. 17, 2000; and International Patent Application Publication No. WO 02/41147 A1, entitled "System And Method For Updating And Distributing Information", filed Nov. 19, 2001, and having publication date Mar. 23, 2002; the entire disclosures of which are incorporated by reference into this application for all purposes

### BACKGROUND OF THE INVENTION

Non-volatile memory is employed in a wide variety of electronic devices such as, for example, mobile handsets, cellular phones, personal digital assistants (PDA's), pagers and handheld personal computers. The non-volatile memory in these devices contain firmware, application software, data, and configuration information that makes the devices operational, and may be provided by the manufacturers of the electronic devices, by system operators of telecommunication carrier networks, or by third parties developers. If defects are found in such firmware/software, or if new features are to be added to such devices, the software and/or firmware in the affected electronic devices may need to be updated. Errors and/or interruptions that may occur during the updating of such operational code may leave the electronic device in a partly or completely non-functional state. To avoid this problem, present methods of updating such software and/or firmware involve returning the electronic device to the manufacturer, to the system operator, or to the third party, so that an update of memory contents may be performed using a direct connection to the electronic device. This is both costly and inconvenient to both the user of the electronic device, and to one performing the update.

Configuration parameters and other information for an electronic device may be stored in the non-volatile memory of such devices, and information about the device capabilities, the hardware, software and manufacturer of the device, and particulars for a given instance of the device in a network may be stored in databases used by, for example, device management and customer service operations. Such databases may be accessible to device management and customer service operations through database access mechanisms using, for example, structured query language (SQL) or similar database management tools.

Updates to firmware and/or software in an electronic device may be developed by a number of parties including, for example, the manufacturer of the electronic device, the provider of services of a communication network accessed by the electronic device, or a third party. Users may subscribe to multiple network-based information services, and may receive numerous messages at the electronic device concern-

ing information available, scheduled events, news, and the like. The volume of such information may impair the user's ability to maximize enjoyment and usefulness such services.

Electronic devices such as, for example, cellular phones and wireless enabled personal digital assistants are highly capable. A particular user of such a device, however, is limited by the common functionality offered to all users of a particular make, model and/or version of device. Customization of device capabilities is complex or not unavailable, and users/subscribers may not be aware of, or may find it difficult to learn how to perform personalization of their mobile device. This is particularly true of mass market devices. Customers wishing to tailor the features and capabilities of a device to their needs and wants may seek help from, for example, a customer care representative of the device manufacturer or the provider of wireless network service, but may find that support is poor or non-existent. Point-of-sale centers for such devices also frequently do not provide personalization services. Customer care representatives may be unable to determine what can be personalized in the particular device of the user/subscriber and/or may be untrained and/or unable to help the user/subscriber with such services.

In many cases, personalization of electronic devices may involve firmware, software application, and/or configuration parameter updates. The vast majority of users/subscribers have no idea what is involved, and are not capable of determining the impact such updates on other software applications, on device firmware and/or features of the electronic device. In some cases, the electronic device of a user/subscriber may not be functioning properly, which can complicate any upgrade/customization effort. Firmware, application software, and/or configuration parameters may be out of date. Customer care representatives may be not know or be equipped to determine the effects of a particular update on each of the vast array of electronic devices in use, and may be of little help in furthering user progress in customizing the functionality and user interface of those electronic devices.

During an actual update to firmware, software applications, and/or configuration parameters in an electronic device, a user/subscriber may find themselves staring at the device, waiting for the update activity to complete. Many users/subscribers are anxious about personally performing an update, and may find this a stressful yet boring task. In some cases, no indication is provided on the electronic device to show the progress of such update activities, and the user/subscriber is left uneasily wondering whether the update is proceeding normally, or whether the update has gone awry and left the device non-functional. In general, the user/subscriber experience during firmware, software application, and device configuration updates is very poor.

Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with the present invention as set forth in the remainder of the present application with reference to the drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective block diagram of an exemplary network that supports remote update of non-volatile memory of an electronic device such as, for example, a mobile handset or personal digital assistant, in accordance with a representative embodiment of the present invention.

FIG. 2 is a perspective block diagram of an exemplary network that supports personalization of an electronic device

that may correspond to, for example, the electronic device of FIG. 1, in accordance with a representative embodiment of the present invention.

FIG. 3 shows a block diagram illustrating an exemplary dependency information table for use in dependency management, in accordance with a representative embodiment of the present invention.

FIG. 4 is a flowchart illustrating an exemplary method of managing dependencies that exist between an update to firmware, application software, and/or configuration information and other firmware/software components in an electronic device such as, for example, the electronic device of FIG. 2, in accordance with a representative embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

Aspects of the present invention relate generally to the personalization of mobile devices and, more specifically, to the installation and update of new applications on the mobile devices. While the following discussion focuses primarily on mobile electronic devices such as, for example, a mobile handset, a cellular phone, a personal digital assistant, a pager, and a handheld personal computer, this is by way of example and not by way of specific limitations of the present invention. The teaching contained herein may also be applicable to a variety of other electronic devices having a processor and memory containing software, firmware, configuration information, data files, and the like, for which updating of memory contents may be desirable.

Representative embodiments of the present invention may be employed during updates using wired or wireless communication links such as, for example, a public switched telephone network, a wired local or wide area network, an intranet, the Internet, and wireless cellular, paging, local area, personal area, and short range networks such as those referred to as WiFi, IEEE 802.11 a/b/g/n compatible networks, the short range wireless technology known as Bluetooth, and similar types of communication links.

In a representative embodiment of the present invention, information for updating memory in an electronic device such as those described above may be communicated using, for example, an update package comprising a set of instructions executable by firmware and/or software in the electronic device to transform or convert an existing version of software, firmware, and/or data in the electronic device into a new or updated version of the software, firmware, and/or data. Such an update package may also contain metadata related to the update.

FIG. 1 is a perspective block diagram of an exemplary network 105 that supports remote update of non-volatile memory of an electronic device 107 such as, for example, a mobile handset or personal digital assistant, in accordance with a representative embodiment of the present invention. The electronic device 107 may, for example, comprise a cellular phone, a personal digital assistant (POA), a pager, a handheld personal computer (PC), and/or the like. The electronic device 107 may support a number of features and/or applications that may contain software/firmware errors that need to be corrected, or that may provide additional features/benefits by updating the software/firmware. The electronic device 107 may itself be used to request updates to software/firmware via a customer care server 157 either directly, using a browser in the electronic device 107, or via a customer service representative (CSR). A CSR may, for example, provide service to the customer using the electronic device 107 by retrieving, as necessary, one or more diagnostic manage-

ment objects (MOs) stored in memory of the electronic device 107, and by transmitting to the electronic device 107 from a remote server, update information in the form of, for example, one or more update packages. Such update packages may, for example, comprise instructions to code in the electronic device 107 to convert or transform a first version of software/firmware to a second version of software/firmware, in the electronic device 107, in addition to metadata, and checksum information.

As shown in the illustration of FIG. 1, the network 105 in one representative embodiment of the present invention comprises the electronic device 107, a device management (DM) server 109, a provisioning server 129, a customer care server 157, and a download server 151. Although not illustrated in FIG. 1, a representative embodiment of the present invention may also comprise other application servers such as, for example, a diagnostics server, and a self-care website/portal. The electronic device 107 of FIG. 1 is able to communicate with the DM server 109, the download server 151, the customer care server 157, and the provisioning server 129 via communication paths 143, 153, 155 and 145, respectively. Although the communication paths 143, 153, 155, 145 are illustrated as being separate paths between the electronic device 107 and their respective servers, this is only for purpose of illustration, and is not a specific limitation of a representative embodiment of the present invention. The communication paths 143, 153, 155, 145 may be combined into one or more paths that may comprise wired or wireless communication paths such as, for example, a local area network, a public switched telephone network, a wireless personal, local or wide area network, and a cellular or paging network, to name only a few possibilities.

As illustrated in FIG. 1, an electronic device in accordance with one representative embodiment of the present invention comprises a processor 166, random access memory (RAM) 165, and non-volatile memory (NVM) 111. The NVM 111 may comprise, for example, NAND or NOR type flash memory or other suitable type of NVM. The NVM 111 may contain a number of software/firmware code components of the electronic device 107 including, for example, application software 127, a device management (DM) client 163, an update package/update package array 116, a provisioning client 123, a hand-off module 121, an operating system (OS) 119, firmware 117, and one or more update agent(s) 115. Additional software/firmware code components may also be present in the RAM 165 and NVM 111. The term “code” is used herein to represent one or more of executable instructions, operand data, configuration parameters, and other information stored in memory of the electronic device 107, and the term “update package catalog” is used interchangeably with the term “update package array” to refer to received update information that comprises multiple update packages. In some representative embodiments of the present invention, the electronic device 107 comprises interface circuitry (not shown) to enable operable connection of a subscriber identity module (SIM) card 167, that may be employed in accordance with aspects of the present invention described later in this document.

In a representative embodiment of the present invention, an electronic device such as, for example, the electronic device 107 of FIG. 1 employs an update package (e.g., the update package/update package array 116) delivered by a remote server such as, for example, the download server 151, to update firmware/software, data and configuration information in memory of the electronic device 107. Such an update package comprises update information including, for example, metadata describing an update, checksums, and

instructions executable by one or more update agents such as, for example, the update agent 115 of FIG. 1. The update agent 115 in one representative embodiment of the present invention processes a set of executable instructions, which are used as a compact means to encode differences between existing/first and updated/second versions of firmware, software, data, and configuration parameters for the electronic device 107. In such an embodiment, the executable instructions are assembled into one or more update packages to be transmitted to an electronic device for use in updating memory of the electronic device. Update agent(s) in the electronic device process respective portions of the executable instructions from an update package to convert/transform corresponding portions of the existing/first version of code in memory of the electronic device 107 to portions of the updated/second version of code. The electronic device 107 may also receive provisioning information from, for example, the device management server 109, the customer care server 157, and/or the provisioning server 129 to fix configuration problems or reconfigure software and hardware.

In addition to those elements described above, in some representative embodiments of the present invention the electronic device 107 comprises a downloaded diagnostic client (not shown) that facilitates remote diagnosis, and/or a traps client (not shown) that facilitates the setting of traps and retrieving of collected information. In such embodiments, the DM client 163 of the electronic device 107 interacts with the DM server 109, the diagnostic client, and the traps client, to receive DM commands from the DM server 109 and to implement them in the electronic device 107. The download server 151 is employed to download firmware and software updates (e.g., update information in the form of, for example, update packages). In some representative embodiments of the present invention, the download server 151 is used to download new firmware/software such as, for example, the diagnostics client mentioned above, which is then installed and activated in the electronic device 107.

As described briefly above, an electronic device in accordance with some representative embodiments of the present invention (e.g., electronic device 107) receives update information (e.g., an update package) for processing by one or more update agents (e.g., update agent 115) to convert/transform software (e.g., application software 127) and/or firmware (e.g., firmware 117) to produce updated software/firmware in the electronic device. In some representative embodiments of the present invention, the update agent 115 comprises multiple update agents, each of the update agents appropriately arranged to process different types of update information for updating different types/formats of software, firmware, user data, and configuration parameters in the memory of the electronic device 107. In such embodiments, each of the update packages received are processed in the electronic device by an appropriate one of the update agent(s) 115 to update an associated type of information in the memory of the electronic device 107.

Some representative embodiments of the present invention employ an Open Mobile Alliance (OMA) device management DM-based applications server composed of two parts, an OMA DM-based application, and an OMA DM server such as, for example, the DM server 109 shown in FIG. 1. An OMA DM-based application is mainly focused on business processes, logic, and data. An OMA DM server, however, is mainly focused on the functionality required to support the OMA DM protocol by which the OMA DM-based application manipulates OMA DM-capable electronic devices such as, for example, the electronic device 107 of FIG. 1.

FIG. 2 is a perspective block diagram of an exemplary network 205 that supports personalization of an electronic device 207 that may correspond to, for example, the electronic device 107 of FIG. 1, in accordance with a representative embodiment of the present invention. As is shown in the example of FIG. 2, the electronic device 207 in some representative embodiments of the present invention comprises a number of applications and/or features that a user of the device may desire to update or personalize at some point in the life of the electronic device 207. In one representative embodiment of the present invention, a request to begin personalization of the electronic device 207 is entered by a user/subscriber using the user interface of the electronic device 207 itself. In other representative embodiments, a request to begin personalization of the electronic device 207 may be entered using a personal computer and browser accessing an Internet web page-type user interface. Either user interface (e.g., that of the electronic device 207 or web-based) may be used to request personalization service via a content manager server such as, for example, the content manager server 251 shown in FIG. 2. In a representative embodiment of the present invention, the content manager server 251 provides a service to the user/subscriber/customer of the electronic device 207, by retrieving one or more elements of personalization content and forwarding it to the electronic device 207. In addition, the network 205 comprises a DM server 125 communicatively coupled to the electronic device 207 and a service provider server 229 also communicatively coupled to the electronic device 207. The electronic device 207 comprises a DM client 263, firmware 217, an operating system 219, an update agent 215, and an application software 227.

The network 205 helps manage the user experience during a firmware/software update of the electronic device 207 by, for example, displaying information, advertisements, and promotions on the display of the electronic device 207, during the update process. In some representative embodiments of the present invention, the display of such advertising and informational content employs a server such as, for example, the DM server 209 or another server (e.g., content management server 251) in the network 205. For example, the DM server 209 may set up the display of advertisements and information by communicating with the electronic device 207 using a device management protocol such as, for example, an Open Mobile Alliance (OMA) device management (DM) protocols. The development of the OMA DM protocol has been under the guidance of the Open Mobile Alliance, Ltd. Arranging for display of advertising and informational content during updates of the electronic device 207 may take place, for example, during a device discovery session between a server such as the DM server 209 and the electronic device 207. In one representative embodiment of the present invention, once the update of the electronic device 207 starts, the update agent 215 in the electronic device 207 pulls display information, advertisements, and promotion material, for example, from downloaded content stored in the electronic device 207. In other representative embodiments, the advertising, promotional, and information content may be pushed to the electronic device 207. The exchange of such information between a remote server and the electronic device 207 may use one or both of the OMA DM and OMA Download protocols. This may include defining a new set of management objects in a device management tree in memory of the electronic device 207, which will be used to point client software in the electronic device 207 to correct download locations (e.g., universal resource locators (URLs)) of the content. In some representative embodiments of the present

invention, multiple contents download locations are supported, and multiple content packages of advertising, promotional and information content are supported. In some representative embodiments of the present invention, the content and URLs used are dynamically selected during the session based upon segmentation of users as well as the electronic devices in use. An addressing method using fixed or dynamic locations that communicate the location of advertising, promotional, and information content allows for staging content on the electronic device 207 before commencing an update, and then displaying the content during the update activity.

In some representative embodiments of the present invention, the update agent 215 performs this display of advertising, promotional, and/or information content without the use of the capabilities of the operating system of the electronic device 207. In such an embodiment, the update agent 215, for example, displays content to the user. In some representative embodiments of the present invention, such downloaded content is contained in an update package used to contain update information for the update of the firmware, application software and/or configuration parameters. In other representative embodiments, the advertising, promotional, and/or information content may be separate from the update information used for updating firmware and/or software. This permits the advertising, promotional and/or information content to be tailored for individual users or groups of users of the electronic device 207, separately from update information for the electronic device 207. In one representative embodiment of the present invention, the advertising, promotional and/or information content to be displayed is selected by, for example, the DM server 209 and/or the content management server, based upon the nature of the personalization and/or update(s) being performed upon the electronic device 207. For example, a user that requests personalization of the electronic device 207 to include access to video or audio playback of media content may be presented with advertisements, and promotional, and/or information content related to various video and/or audio content available, the existence of groups of individuals having interest in certain video and/or audio content, advertisements for related services and/or related upgrades for their electronic device, and the like. In representative embodiments of the present invention, such advertising, promotional and/or information content is dynamically displayed, in a sequence and timing defined by the advertiser/content provider (e.g., from content provider server 235) and/or the provider of services/updates for the electronic device 207 (e.g., the service provider server 229 and/or the DM server 209). In this manner, an embodiment of the present invention enhances the user experience during updates of the electronic device 207, with the display/rendering of promotions, advertisements or other information.

As a part of providing updates to firmware, application software, and configuration parameters, the network 205 of some representative embodiments of the present invention handle dependency management while updating the electronic device 207. As used herein, the term “dependency management” is defined as the process of ensuring that all firmware, software, and configuration parameters needed for a given update to function in the electronic device 207 are identified, and that all are present in the electronic device 207, following completion of the installation of the update.

A representative embodiment of the present invention may be employed to handle dependency management in embedded devices an electronic device with an operating system such as, for example, the operating system 219 of the electronic device 207 of FIG. 2. In a representative embodiment of the present invention, a server such as the DM server 109,

the content management server 251, or a download server (not shown) facilitates management of dependencies between elements of an update to the electronic device 207. An exemplary method for updating/installing firmware, application software and/or configuration information on the electronic device 207 that employs dependency management is described below.

FIG. 3 shows a block diagram illustrating an exemplary dependency information table 300 for use in dependency management, in accordance with a representative embodiment of the present invention. In one representative embodiment of the present invention, each electronic device (e.g., electronic device 207) has, for example, a table 300 containing multiple entries 310, 312, 314, 316 list each of the packages 320 (e.g., firmware/software components or applications) that are installed on the electronic device 207, the corresponding version numbers 322 of those packages, and a list of the dependencies 324 of the package (e.g., firmware/software components/configuration information needed for the use of the package). In one representative embodiment of the present invention, the information in the dependency information table 300 is set at the time of manufacture, and is maintained by the electronic device over its life as it is updated. An inventory inquiry may be used by a server such as, for example, the DM server 209, to retrieve this information from the electronic device 207, if the server has need for this information. In another representative embodiment, such a dependency information table may be maintained by a remote server (e.g., DM Server 209, content management server 251, or service provider server 229), and provided to the electronic device 207 when needed. In some representative embodiments of the present invention, each electronic device 207 also has a list of standard sources from which new packages (e.g., firmware, application software, and configuration information) can be downloaded.

FIG. 4 is a flowchart illustrating an exemplary method of managing dependencies that exist between an update to firmware, application software, and/or configuration information and other firmware/software components in an electronic device such as, for example, the electronic device 207 of FIG. 2, in accordance with a representative embodiment of the present invention. Appropriate changes to the method described below may be made without departing from the scope of a representative embodiment of the present invention, to accommodate the level of support provided by various operating systems that may be employed in the electronic device 207. The method of FIG. 4 begins at step 410, at which an electronic device such as, for example, the electronic device 207 requests that the provider of an application update such as, for example, the DM server 209, the service provider 123 or the content management server 133 of FIG. 2, supply a list of dependencies of the application update. The list of dependencies also includes any dependencies that the dependencies may have. It should be noted that the use of a “list of dependencies” is for purposes of illustration, and that information identifying “higher-order” dependencies (i.e., dependencies of dependencies) need not be explicitly stored in a list, but may be determined when needed by analyzing a graph of the dependencies of the various firmware/software components/packages to be made functional in the electronic device 207. For example, if package A is dependent upon package B, and package B is dependent upon package C, then analysis of a list of firmware/software components/packages to produce a dependency graph would allow one to determine that package A depends upon package C. The provider supplying the application update may be on the list of standard

sources of updates, mentioned above, or may be an independent provider of application updates for the electronic device 207.

Next, at block 412, the method of FIG. 4 determines which dependencies are not present on the electronic device 207, by comparing the list of dependencies of the application, to the list of software components/packages installed on the electronic device 207 (e.g., table 300 of FIG. 3). Next, the method (at block 413) automatically retrieves all dependencies not already on the electronic device 207. The method of FIG. 4 then calculates, at block 414, the memory space needed on the electronic device (e.g., electronic device 207) to install the application update and the dependencies of the application update that are not already installed on the electronic device 207. It should be noted that the amount of memory space temporarily needed to perform the update in the electronic device 207 may be different than the amount of space occupied by the application and its dependencies following completion of the update process. A representative embodiment of the present invention accurately calculates the memory space needed so that a determination may be made as to whether the update process can be completed, before the package of update information is sent to the electronic device 207, and before any updating of memory in the electronic device is attempted. This avoids possible failure of an update, and corruption of memory in the electronic device 207.

Next, at block 416, a determination is made whether there is sufficient memory on the electronic device 207 for the application update, all of its dependencies, and any dependencies of the dependencies. If it is determined that insufficient memory is available then, at block 422, the update of the electronic device is aborted. If, however, it is determined that sufficient memory is available then, at block 418, the method of FIG. 4 automatically generates a single package of update information for the application update, including any dependencies not already present on the electronic device 207 (e.g., from the list of standard sources or an independent source). Such an update package may be generated by determining differences between an image of memory of the electronic device 207 with the application update and any dependencies of the application update, and an image of memory containing the existing software/firmware present in the electronic device 207, for example. Such differences may be expressed as a set of instructions executable by the update agent 215 of FIG. 2. The execution of such instructions may use the existing contents of memory in the electronic device 207 to generate an updated version of memory containing the application and all dependencies. The method, at block 419, then downloads the update information to the electronic device 207 and, at block 420, an update agent in the electronic device processes the downloaded update information to perform the update of memory in the electronic device 207.

A representative embodiment of the present invention identifies and collects all dependencies needed for an update to the electronic device 207, without requiring the involvement of the user in retrieving and downloading the needed components. In this manner, the user of the electronic device 207 need not search for and retrieve software/firmware components needed for an update, but instead a representative embodiment of the present invention creates a single package of update information on-the-fly that provides the electronic device of the user with all needed software/firmware components, automatically. The generation and use of a single package of update information can be expected to result in a greater efficiency in terms of the size of the update information used compared to the size of the software/firmware being updated/installed. In a representative embodiment of the

present invention, the update created for one user may also be saved and later distributed to one or more other users having the same electronic device 207, and desiring the same updates.

It should be noted that a representative embodiment of the present invention conserves memory in the electronic device 207 by maintaining a list of only those packages that are present on the electronic device 207. In addition, in some representative embodiments of the present invention, the list of dependencies of the update provided at block 410 by a remote server (e.g., DM server 209) includes only those packages that are known to be installed on the electronic device 207.

In addition, it should be noted that a representative embodiment of the present invention conserves memory in the electronic device 207 by employing updates that are differentially compressed. That is, the update information sent to the electronic device 207 represents the differences between the prior memory image and the updated memory image of the electronic device 207.

The update agent (e.g., update agent 215) in some representative embodiments of the present invention takes into account that the amount of memory used in the electronic device 207 during an update may be expected to be greater than that used when the update process is completed.

The above example demonstrates a representative embodiment of the present invention that may be employed in an electronic device having an operating system. Other representative embodiments of the present invention may be employed to support dependency management in embedded devices without an operating system. For example, the electronic device 207 may be configured without an operating system, and may instead have embedded firmware that provides a rudimentary file system. In such a situation, an application installed by a user is likely to make calls to functions in the existing firmware of the electronic device. If the firmware in the electronic device is updatable, this may present a problem, since entry points for functions used by an application may change from an existing version of the firmware to an updated version. This issue with dynamic library access may arise on all kinds of computers, and is not limited to just embedded devices such as the electronic device 207 of FIG. 2. Two possible solutions to this issue include 1) perform calls through a jump table in the existing firmware, or 2) store a table of relocation entries with each application.

In a representative embodiment of the present invention, a jump table used to perform calls into the existing firmware is updated when the firmware is updated. Each jump table entry provides an indirect entry point to a function within existing firmware. As long as the relative offsets of the function entry points within the jump table don't change, then applications accessing firmware through the jump table entry points do not need to change when firmware is updated.

Another representative embodiment of the present invention stores a table of relocation entries with each application. Each relocation entry is a location within an application that is to be patched when the firmware of the electronic device changes, and may include instructions for how to do the patching. Some representative embodiments of the present invention consume less space to represent such patches by, for example, storing just the locations of references that are not correctly disassembled by a reference disassembler application. This approach involves partially re-linking the application to the firmware, on the electronic device. Some representative embodiments of the present invention resolve such relocation entries at run time, if the application is loaded into RAM. The use of a table of relocation entries saves a level of

indirection when compared to the use of a jump table, but may involve a larger number of changes (and, therefore, writes to flash non-volatile memory) if there are many applications to be updated as a result of an update to the firmware of the electronic device 207. Updates of the electronic device 207 that may employ such techniques of dependency management include, for example, games and sounds that can be downloaded into the electronic device 207.

In some representative embodiments of the present invention, the network 205 supports updating the electronic device 207 by providing support for an OS-independent file system update process. Such a process employs an OS-agnostic comprehensive procedure to create and update the electronic device 207 using appropriate update packages. The OS agnostic procedure is adapted to each operating system with minimum changes. The procedure identifies and formalizes the common operations performed during software installations like the creation or modification of:

- Shared and non-shared program files
- Folders/directories
- Installation and updates logs and dependencies
- Configuration file entries
- Environment variables
- Links or shortcuts

In a representative embodiment of the present invention, the network 205 enables updates to the electronic device 207 by providing support for the update of mixed-mode mobile devices. An electronic device such as the electronic device 207 such as, for example, a mobile phone, may be referred to as a mixed-mode mobile device if it is capable of using a number of different communication technologies (e.g., wireless protocols) for exchanging digital information. For example, a mobile phone may be capable of using standard Global System for Mobile Communications (GSM) service (that may be expensive to use), or Institute of Electrical and Electronics Engineers, Inc. (IEEE)-802.11 (Wi-Fi) protocols (that may be inexpensive to use) for downloading/exchanging update information. Some representative embodiments of the present invention employ software/firmware on both the client and server side that coordinates the use of lower cost and more-expensive modes of communication to save the user money, while providing the same information to the electronic device 207 of the user.

In one representative embodiment of the present invention, an electronic device such as the electronic device 207, for example, downloads a rough/lower bit rate version of an MP3 audio file when a user is sitting in highway traffic and only has GSM connectivity. The user may, for example, be in a car riding on an interstate highway. Such an environment is not a good location in which to critically listen to music, so a rough/lower quality/lower bit rate version may be quite acceptable. However, in a representative embodiment of the present invention, when the user arrives at a location that has a higher bandwidth connectivity available (e.g., IEEE-802.11 (i.e., Wi-Fi) connectivity), the electronic device (e.g., a mobile phone) automatically downloads a better/higher quality/higher bit rate version for playback via the user's stereo in his/her home. In some representative embodiments of the present invention, such a download is a differential download that sends only the information required to complete the content of the higher bit rate version of the rougher/lower quality version previously downloaded at a lower bit rate. By employing such a "progressive download" approach, a representative embodiment of the present invention permits a user to have a usable copy of content appropriate for the user's willingness to pay and network environment, but to later acquire a higher-quality copy suitable for use in a different

environment and at a different time, without the need to purchase/download two complete copies of the desired content. A representative embodiment may upgrade such lower-quality content automatically, when an appropriate communication network is detected to be available for use.

Another representative embodiment of the present invention may download information when a higher bandwidth/less expensive connection is available, in anticipation of later use of the information when such a high bandwidth/low cost link may not be available. For example, in one representative embodiment of the present invention, an electronic device such as, for example, the electronic device 207 of FIG. 2 would download web pages that the user usually reads before the user leaves home in the morning. Then, the electronic device may differentially update the downloaded web pages, while the user is on the train, using a different type of communication path. In a representative embodiment of the present invention, the initial download at home employs, for example, an inexpensive Wi-Fi connection to download the bulk of the information to the electronic device 207, while the later differential update on the train uses, for example, a more expensive cellular wireless connection (e.g., COMA, GSM, etc.) to download a much smaller amount of information.

In yet another representative embodiment of the present invention, voicemail or email messages are preemptively downloaded when the user is in Wi-Fi range, even if the user hasn't yet made a request for such messages. The user of the electronic device may set one or more criteria that when met, cause the electronic device to perform exchanges of information of interest to the user. For example, the user may set the criteria to include a cost of transferring a unit of information, a time during which or before which an update should be completed. The user may set a preference for the type of communication path, or the reliability of the path to be used. The user may set how often differential updates should be performed, or the maximum age of information before a new update is attempted. And the user may request email/voicemail from particular sending parties be downloaded/retrieved ahead of all others, or at more frequent intervals. By downloading information to the electronic device 207 when the cost/bandwidth of an available communication service meets a user set criteria, a representative embodiment of the present invention allows a user to maximize the utility and adjust costs to meet the desires of the user.

The network 205 in a representative embodiment of the present invention supports differentially maintaining data in the electronic device 207. For example, a user-selected list of restaurants within a two-mile radius of a user's vehicle may be kept updated using differential updating/compression, depending on how fast the user is driving. Depending upon the type of information being exchanged, such a representative embodiment may employ a data format that is good for generic content such as, for example, media content, or other more efficient data formats for use with other types of digital content (e.g., speech, text, still images, graphics). In one representative embodiment of the present invention, compressed data stored in the electronic device 207 is updatable, and the data format used for the compressed data provides random access to the data.

As described above, a representative embodiment of the present invention supports dependency management for file system component updates and application updates in an electronic device such as the electronic device 207, via the network 205. In addition, during firmware or a component update process, a representative embodiment of the electronic

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device 207 may be configured to display advertisements, promotions, and information to the user to enhance the user experience.

Although a system and method according to the present invention has been described in connection with the preferred embodiment, it is not intended to be limited to the specific form set forth herein, but on the contrary, it is intended to cover such alternative, modifications, and equivalents, as can be reasonably included within the scope of the invention as defined by this disclosure and appended diagrams.

Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computer system, or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. An electronic device comprising:

at least one processor;  
a memory; and

one or more programs, wherein the one or more programs are stored in the memory and configured to be executed by the at least one processor, and wherein the one or more programs include instructions configured to:

access a list of dependencies of a software and/or firmware application to be installed, wherein a dependency comprises a software and/or firmware component used by, but not part of, the software and/or firmware application to be installed;

compare the list of dependencies to a list of all software and/or firmware components already present in the memory;

produce a dependency graph to determine a number of dependents of the list of dependencies;

automatically retrieve all dependencies and dependents of the list of dependencies not already present in the memory;

determine whether room is available in the memory for the software and/or firmware application, all depen-

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dependencies, and dependents of the list of dependencies not already present in the memory;

download update information for installing the software and/or firmware application and all dependencies not already present in the memory, via a communication network, if room is available in the memory; and process the downloaded update information.

2. The electronic device of claim 1, wherein the one or more programs further include instructions configured to enable a set of user criteria.

3. The electronic device of claim 2, wherein downloading the update information for installing the software and/or firmware application and all dependencies not already present in the memory occurs only if the set of user criteria are met.

4. The electronic device of claim 2, wherein the set of user criteria include at least one of a cost of transferring a unit of information, a type of communication path, and a frequency for performing differential updates.

5. The electronic device of claim 1, wherein the electronic device is a mobile device.

6. The electronic device of claim 5, wherein the electronic device comprises one of a cellular phone, a personal digital assistant, and a pager.

7. The electronic device of claim 1, wherein the communication network is a wireless network.

8. The electronic device of claim 1, wherein the list of all software and/or firmware components already present in the memory is maintained by the electronic device.

9. The electronic device of claim 1, wherein the list of all software and/or firmware components already present in the memory is maintained by a server remote from the electronic device.

10. The electronic device of claim 1, wherein processing of the downloaded update information uses existing contents of the memory to produce the software and/or firmware application and all dependencies not already present in the memory.

11. A computer-program product tangibly embodied in a non-transitory machine-readable storage medium, the computer-program product including instructions configured to cause a data processing apparatus to:

access a list of dependencies of a software and/or firmware application to be installed, wherein a dependency comprises a software and/or firmware component used by, but not part of, the software and/or firmware application to be installed;

compare the list of dependencies to a list of all software and/or firmware components already present in a memory of an electronic device;

produce a dependency graph to determine a number of dependents of the list of dependencies;

automatically retrieve all dependencies and dependents of the list of dependencies not already present in the memory of the electronic device;

determine whether room is available in the memory of the electronic device for the software and/or firmware application, all dependencies, and dependents of the list of dependencies not already present in the memory of the electronic device;

download update information for installing the software and/or firmware application and all dependencies not already present in the memory of the electronic device to the electronic device, via a communication network, if room is available in the memory of the electronic device; and

process the downloaded update information by the electronic device.

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12. The computer-program product of claim 11, further including instructions configured to cause a data processing apparatus to enable a set of user criteria.

13. The computer-program product of claim 12, wherein downloading the update information for installing the software and/or firmware application and all dependencies not already present in the memory of the electronic device occurs only if the set of user criteria are met.

14. The computer-program product of claim 12, wherein the set of user criteria include at least one of a cost of transferring a unit of information, a type of communication path, and a frequency for performing differential updates.

15. The computer-program product of claim 11, wherein the electronic device is a mobile device.

16. The computer-program product of claim 15, wherein the electronic device comprises one of a cellular phone, a personal digital assistant, and a pager.

17. The computer-program product of claim 11, wherein the communication network is a wireless network.

18. The computer-program product of claim 11, wherein the list of all software and/or firmware components already present in the memory of the electronic device is maintained by the electronic device.

19. The computer-program product of claim 11, wherein the list of all software and/or firmware components already present in the memory of the electronic device is maintained by a server remote from the electronic device.

20. The computer-program product of claim 11, wherein processing of the downloaded update information uses existing contents of the memory of the electronic device to produce the software and/or firmware application and all dependencies not already present in the memory of the electronic device.

21. A computer-implemented method, comprising:  
accessing a list of dependencies of a software and/or firmware application to be installed, wherein a dependency comprises a software and/or firmware component used by, but not part of, the software and/or firmware application to be installed;  
comparing the list of dependencies to a list of all software and/or firmware components already present in a memory of an electronic device;  
producing a dependency graph to determine a number of dependents of the list of dependencies;  
automatically retrieving all dependencies and dependents of the list of dependencies not already present in the memory of the electronic device;

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determining whether room is available in the memory of the electronic device for the software and/or firmware application, all dependencies, and dependents of the list of dependencies not already present in the memory of the electronic device;

downloading update information for installing the software and/or firmware application and all dependencies not already present in the memory of the electronic device to the electronic device, via a communication network, if room is available in the memory of the electronic device; and

processing the downloaded update information by the electronic device.

22. The computer-implemented method of claim 21, further comprising enabling a set of user criteria.

23. The computer-implemented method of claim 22, wherein downloading the update information for installing the software and/or firmware application and all dependencies not already present in the memory of the electronic device occurs only if the set of user criteria are met.

24. The computer-implemented method of claim 22, wherein the set of user criteria include at least one of a cost of transferring a unit of information, a type of communication path, and a frequency for performing differential updates.

25. The computer-implemented method of claim 21, wherein the electronic device is a mobile device.

26. The computer-implemented method of claim 25, wherein the electronic device comprises one of a cellular phone, a personal digital assistant, and a pager.

27. The computer-implemented method of claim 21, wherein the communication network is a wireless network.

28. The computer-implemented method of claim 21, wherein the list of all software and/or firmware components already present in the memory of the electronic device is maintained by the electronic device.

29. The computer-implemented method of claim 21, wherein the list of all software and/or firmware components already present in the memory of the electronic device is maintained by a server remote from the electronic device.

30. The computer-implemented method of claim 21, wherein processing of the downloaded update information uses existing contents of the memory of the electronic device to produce the software and/or firmware application and all dependencies not already present in the memory of the electronic device.

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